ONCOLOGY

Retrospective Analysis of Radiation Load during Examination of Cancer Patients by ^{68}Ga-DOTATOC and ^{18}F-FDG Positron Emission Tomography

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We present retrospective analysis of the results of examinations of 1338 cancer patients by ^{68}Ga-DOTATOC and ^{18}F-FDG positron emission and computer-aided tomography. It was shown that complex devices for positron emission and computer-aided tomography provide more informative data than individual methods. The protocol for examination by methods of positron emission and computer-aided tomography in each case is determined by clinical requirements and risk of extra exposure of the patient.

Key Words: *positron emission tomography; computer-aided tomography; effective exposure dose*

Whole body positron emission tomography (PET) providing unique information about metabolism and perfusion of normal and pathologically modified tissues is one of the most perspective methods used for tumor diagnosis, detection of metastases and relapses, planning of antitumor therapy, and evaluation of its efficiency [1,4,5,10]. The main drawback of PET is difficulty of topical diagnosis of the detected pathological formations and impossibility of evaluating the relationships between the tumor and adjacent organs and tissues [4-6]. For this reason, modern PET scanners are manufactured in configuration with X-ray computer-aided tomographic (CT) scanners. Combination of metabolic (PET) and morphological (CT) information appreciably improves diagnosis of location and dissemination of the tumor process [3-5]. High spatial resolution of multi-detector CT scanners enables detection of small metastases in the lungs, which cannot be detected by PET [10]. In addition, CT data are essential for the correction of PET image attenuation, which reduces the time of the study by 30-40% [4,5]. However, wider diagnostic potentialities of complex PET and CT methods can be associated with higher radiation load [12].

The significance of radiation protection of patients and insufficient information about radiation load during examination by complex PET/CT devices prompted us to evaluate the effective irradiation dose for various PET/CT protocols and the values of radiation exposure of the patient for each of these methods.

MATERIALS AND METHODS

We performed retrospective analysis of the results of examination of 1338 cancer patients with gastrointestinal tumors (28%), non-small-cell lung carcinoma (27%), head and neck tumors (18%), ma-

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lignant lymphomas (18%), and other diseases (9%), carried out at the hospital of Technical University (Dresden) on a Biograph 16 PET/CT scanner (Siemens). Positron emission tomography was carried out 30 min after intravenous injection of 340 MBq ^{18}F-FDG (^{18}F-fluorodeoxyglucose; n=1190) and 120 MBq ^{68}Ga-DOTATOC (n=148); the agents were obtained from department of Nuclear Medicine, Technical University (Dresden), directly before examination.

Standard CT (CT_{st}; tube voltage 120 kV, 100 mA current) without intravenous injection of iodine-containing contrast agents was used for the diagnosis and radiotherapy planning, as well as for the correction of PET image attenuation (n=413 and n=43, respectively).

Low-dose CT (CT_{ld}; tube voltage 120 kV, 10 mA current) without intravenous injection of iodine-containing contrast agents was used only for correction of PET image attenuation (n=720 and n=105, respectively).

Additional CT_{st} with intravenous injection of iodine-containing contrast agents (CT_{ca}) was carried out in cases when it was necessary to determine the stage and volume of intervention and for re-staging (n=766 and n=65, respectively).

Effective dose for the PET protocol was estimated by the equation:

$$E_{PET}=A_{tr}\times K_{PET},$$

where A_{tr} is tracer activity and K_{PET} is a coefficient [8].

Effective dose for CT protocol was estimated by the equation:

$$E_{CT}=eDLP\times DLP,$$

where eDLP is the dose coefficient standardized by DLP (dose length product) for the standard dosimetric phantom [2].

Effective exposure dose for PET/CT ($E_{PET/CT}$ was calculated as the sum of effective doses for PET and CT: $E_{PET/CT}=E_{PET}+E_{CT}$.

RESULTS

The mean E_{PET} values for various ^{18}F-FDG PET/CT and ^{68}Ga-DOTATOC PET/CT protocols were 6.4±0.8 and 2.5±0.6 mSv, respectively (Fig. 1). The same E_{CT} values (1.3±0.2 mSv) were obtained for CT_{ld} in complex with ^{18}F-FDG PET and ^{68}Ga-DOTATOC PET. As a result of optimization of the ^{68}Ga-DOTATOC PET protocol, the CT_{st} doses (E_{CT}) for correction of ^{18}F-FDG PET and ^{68}Ga-DOTATOC PET images attenuation were different (11.7±0.2 and 10.6±3.5 mSv, respectively). Similar differences were obtained for CT_{ca} in complex with ^{18}F-FDG PET (17.1±0.3 mSv) and ^{68}Ga-DOTATOC PET (14.0±5.2 mSv) (Fig. 1).

The use of PET and CT yields correct diagnosis in 75% and 58% cases, respectively. Only combined PET/CT method gave adequate results in 19% cases. On the other hand, no appreciable differences in the informative value of CT_{ld} and CT_{st} were detected.

The appearance of PET/CT scanners, allowing superposition of PET and CT data, is a natural development of modern radiodiagnostic technologies used in oncology [4-6]. The efficiency of using a certain PET/CT protocol is determined by clinical indications [8] and additional radiation loading [2]. Our analysis included cases when PET/CT was carried out for more precise evaluation of tumor location and disease stage. Detailed morphological data (CT_{ca}) were essential for this group of patients in order to supplement functional (PET) information for topical diagnosis and treatment planning, which

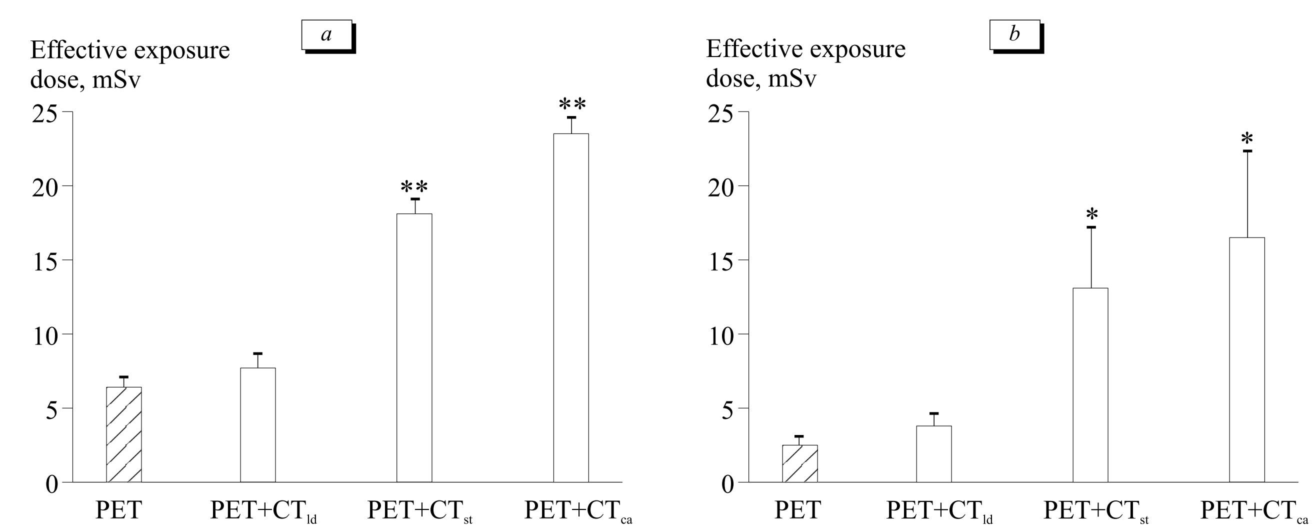

Fig. 1. Radiation load in various PET/CT protocols. *a*) ^{18}F-FDG PET; *b*) ^{68}Ga-DOTATOC PET. $^{*}p$<0.05, $^{**}p$<0.01 compared to PET.

is in agreement with other publications [5]. Radiation load in these cases can be reduced by using CT_{ca} for the diagnosis and for PET image attenuation correction [4]. Another group consisted of patients to whom PET/CT was prescribed additionally during treatment. PET/CT_{ld} and collection of preliminary data were usually sufficient for diagnosis, but in some cases in these groups of patients PET/CT_{ca} were prescribed for clinical indications, for example, in order to determine the exposure field.

Hence, unnecessary radiation exposure can be reduced by using combined PET/CT without deteriorating the informative value of the method.

REFERENCES

1. A. M. Granov, L. A. Tyushin, M. S. Tlostanova, *et al.*, *Vopr. Onkol.*, **49**, No. 5, 563-573 (2003).
2. *Ionizing Radiation, Radiation Safety. Effective Exposure Dose Control in Medical X-Ray Examinations* [in Russian], MUK 2.6.1.1797-03, Moscow (2004).
3. E. V. Levchenko, *Prakt. Onkol.*, **7**, No. 3, 138-144 (2006).
4. M. Ya. Marusina and A. O. Kaznacheeva, *Modern Types of Tomography* [in Russian], St. Petersburg (2006).
5. G. E. Trufanov, V. V. Ryazanov, N. I. Dergunova, *et al.*, *Combined Positron Emission and Computer-Aided Tomography (PET/CT) in Oncology* [in Russian], St. Petersburg (2005).
6. E. I. Tyurin, *Prakt. Onkol.*, **6**, No. 5, 6-10 (2005).
7. T. Beyer, G. Antoch, A. Bockisch, *et al.*, *J. Nucl. Med.*, **46**, No. 3, 429-435 (2005).
8. G. Brix, U. Lechel, G. Ziegler, *et al.*, *Ibid.*, No. 4, 608-613.
9. J. Doll, M. Henze, O. Bublitz, *et al.*, *Nuklearmedizin*, **43**, No. 3, 72-78 (2004).
10. F. M. Mottaghy and S. N. Reske, *Pituitary*, **9**, No. 3, 237-242 (2006).
11. W. A. Weber, *J. Clin. Oncol.*, **24**, No. 20, 3282-3292 (2006).
12. T. H. Wu, T. C. Chu, Y. H. Huang, *et al.*, *Nucl. Med. Commun.*, **26**, No. 4, 323-330 (2005).